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HIGH DEFINITION TELEVISION
TRANSITION SCENARIO FOR TV STATIONS
A CBS WORK-IN-PROGRESS

October 23, 1990

Preliminary Results

HIGH DEFINITION TELEVISION

TRANSITION SCENARIO FOR TV STATIONS

A CBS WORK-IN-PROGRESS

1. INTRODUCTION

High Definition Television is a major technical advance over the present NTSC broadcast system. Having twice the resolution, improved color rendition, a wide screen aspect ratio, and digital stereo sound, HDTV may prove to be the medium of choice for home by the turn of the century.

No regulatory or technical barriers hinder the introduction of wide-band high definition service to the home through the distribution media of home video, cable, or direct broadcast by satellite.

Terrestrial broadcasting, however, in attempting to compete with these new high quality services, faces a special challenge. High definition television intrinsically requires a greater transfer of information than can be obtained within the 6 MHz currently allowed for by NTSC television. The radio frequency spectrum is crowded, and the limited spectrum available precludes an unlimited allocation for the use of a new wide bandwidth terrestrial transmission system.

Past Chairman of the FCC, Dennis Patrick, formed an Advisory Committee in Advanced Television Service (ACATS) in 1987, with a mandate to study and test proposed systems for the terrestrial broadcast of Advanced

Television, and to make recommendations for the selection of a standard.

Under the chairmanship of Richard Wiley, a past Chairman of the FCC, ACATS has made much progress in the last three years. In 1988 the FCC tentatively decided that HDTV service should be integrated with and be compatible with the existing NTSC service and its tradition of localism and diversity. Further, the FCC found that HDTV service should not impair or restrict current NTSC broadcast service.

In 1989, Alfred Sikes became Chairman of the FCC, and under his leadership, the FCC announced that a terrestrial transmission standard would be chosen by the middle of 1993.

Secondly, Chairman Sikes determined that priority should be given to the selection of a simulcast system in which TV stations would broadcast both a NTSC and a HDTV signal.

Further, Chairman Sikes has emphasized that the public interest is best served by the adoption of a technically excellent standard.

The ACATS work continues, with three subcommittees, 13 working parties and numerous Specialist Groups, together involving some 450 experts in many fields. Three interim reports have been presented to the FCC.

In 1988, CBS defined requirements of a HDTV terrestrial broadcast system:

- (i) Existing NTSC service should continue unimpaired during the transition period.
- (ii) The broadcast system should be competitive in quality with that provided by other non broadcast distribution media.
- (iii) The system should provide technical headroom for future improvements in order to retain competitive parity.
- (iv) The propagation system should be spectrum efficient.
- (v) The transmission system format should be capable of interfacing with other distribution media.

In addition to detailed spectrum studies and the test and evaluation of proposed systems, ACATS is developing assessments of the cost of converting local TV stations for HDTV terrestrial broadcast. This work is being performed by the System Subcommittee's Working Party 3.

CBS is contributing to this effort with an ongoing study of the costs of implementing HD terrestrial broadcast service, and this interim report details the results to date.

While recognizing that ATV service using improved and extended definition TV technology may prove attractive from the broadcasters' point of view, this study is concerned only with full HDTV service. This is in accord with present FCC policy, which is to first assess a high definition —and not an extended definition, or EDTV—transmission standard.

Following Chairman Sike's policy directive, this report considers only HDTV simulcast systems. A simulcast system is one in which the existing NTSC broadcast channel remains unimpaired (an FCC requirement), and a second 6 MHz channel is allocated for the transmission of HDTV programs. Thus, a television station may transmit a program in HDTV and NTSC simultaneously.

The simulcast approach will permit system designers the opportunity to seek the best possible system for terrestrial broadcast, and will allow stations to start HD service only when it is economically advantageous for them to do so.

This report thus represents a work-in-progress, and invites a dialogue on the complex issues confronting the industry on the timing, phasing, and the cost of the transition to HD.

The CBS study is continuing, and is supported by important contributions from CBS affiliate stations, who are providing data on their past, current, and projected capital investments, and on the feasibility of adding a HD transmitting antenna to their towers.

2. PREMISES AND ASSUMPTIONS

A number of important working premises and financial assumptions have been made in developing transition scenarios. These are outlined in Figure 1, listed below, and discussed in more detail later.

- (i) Stations in the larger markets will be the first to make the transition to HD, not unlike the introduction of color television.
- (ii) The transition will be conducted in phases, with each phase adding to the HD service provided by a station. Stations in larger markets will complete the transition in a shorter time than smaller market stations who may thus spread the capital investment program over a longer period. This again is similar to the introduction of color.
- (iii) The labor cost of transition is 20% of the investment in capital equipment.
- (iv) The transmission system selected will be all-digital and thus will require a much lower Effective Radiated Power (ERP) than current NTSC systems to reach the same audience. With a resulting, relatively small, HD transmitting antenna, the existing tower can be used.
- (v) The initial prices for equipment are based on developmental and prototype units. For the period considered, with each doubling of the number of units manufactured, the cost will fall by 10% of the initial cost.

SIMULCAST HDTV TRANSITION SCENARIO ASSUMPTIONS

- **LARGER MARKET STATIONS WILL CONVERT FIRST**
- **TRANSITION IN PHASES, SPREAD OVER 5-9 YEARS**
- **LABOR TO INSTALL THE CAPITAL EQUIPMENT:
20% OF CAPITAL EQUIPMENT COST**
- **TRANSMISSION FORMAT WILL HAVE LOWER ERP
THAN NTSC - SMALLER ANTENNA PERMITS
INSTALLATION ON PRESENT TOWER**
- **EACH DOUBLING OF HD EQUIPMENT MANUFACTURED
WILL LEAD TO 10% REDUCTION IN INITIAL COST**
- **EXISTING AUDIO EQUIPMENT WILL BE REUSED, NOT
REPLACED**

FIGURE 1



(vi) Existing plant, studio, and control room audio equipment will be reused, not replaced. It is further assumed that a station has previously converted to stereo.

3. PHASED IMPLEMENTATION

The introduction of a HDTV transmission service at a TV station will be a gradual process and will be implemented in phases. Each phase provides an incremental capability, and builds upon the preceding phases.

(Figure 2) The number of phases, and the nature of the capability added in each phase, may vary from market-to-market or from station-to-station.

Here is one, six-phase scenario:

Phase A: Network Pass-through

This is the minimum conversion necessary to deliver network supplied HDTV programming to a market. An additional transmitter and antenna will need to be purchased and installed, together with an additional studio-transmitter link, using microwave or fiber optics. Additional satellite earth station equipment for the reception of network programs, and some distribution, test, and monitoring equipment will be required. The only local origination is the insertion of station identification announcements.

Phase B: Local Commercials

In phase B, additional equipment will be added by the station to allow for local commercial inserts within the network programs.

SIMULCAST HDTV SCENARIO PHASES OF TRANSITION

PHASE

- A - PASS-THROUGH OF NETWORK HD PROGRAMS**
- B - INSERTION OF LOCAL COMMERCIAL MESSAGES**
- C - PLAYBACK OF NON-NETWORK SYNDICATED
HD PROGRAMS**
- D - LOCAL ORIGINATION OF HD PROGRAMS**
- E - COMPLETE PLANT CONVERSION TO HD**
- F - LOCAL NEWSGATHERING (ENG) IN HD**

FIGURE 2



Phase C: Local Videotape Programming

Video tape equipment will next be added to allow for playback of non-network (syndicated) programming when the network is not supplying HDTV programs.

Phase D: Local Studio Origination

A local station in this phase becomes an HDTV production facility. Phase D will add equipment to allow local production to be staged, recorded, edited, and broadcast.

Phase E: Final Plant Conversion

The entire plant systems are next upgraded, giving the station full HDTV capability. All production and origination, except for news gathering, is in HDTV. At this stage when the network transmits a program only in HDTV, the local station will down-convert the signal for the NTSC simulcast.

Phase F: Electronic News Gathering

This phase requires the conversion of the Electronic News Gathering (ENG) equipment to HDTV. At this point all local production is effected in HDTV, and the HDTV signal will be down-converted for NTSC simulcast.

4. TRANSITION SCENARIO

The six phases of conversion identified above are designed to provide an incremental capability with the completion of each phase. The block diagram in Figure 3 presents the completely converted station, with each phase outlined.

Phase A: - Network Pass-through

Shows the acquisition of an earth station receiving a satellite signal. The signal is decoded and routed to a switcher.

In this first phase, the switcher need only be of relatively simple design, to be expanded in later phases.

A station ID is inserted at this point. The signal is then encoded and fed through the STL to the transmitter and antenna.

Phase B: - Local Commercial Insertion

Two VTRs for the playback of HD commercials are added, feeding an automation switcher. When only NTSC commercials are available, an up-converter may be installed, increasing the 525 lines of NTSC.

Phase C: - Local Playback of Non-Network Programs

Requires the addition of program VTR's and a routing switcher.

HD STATION CONVERSION BLOCK DIAGRAM

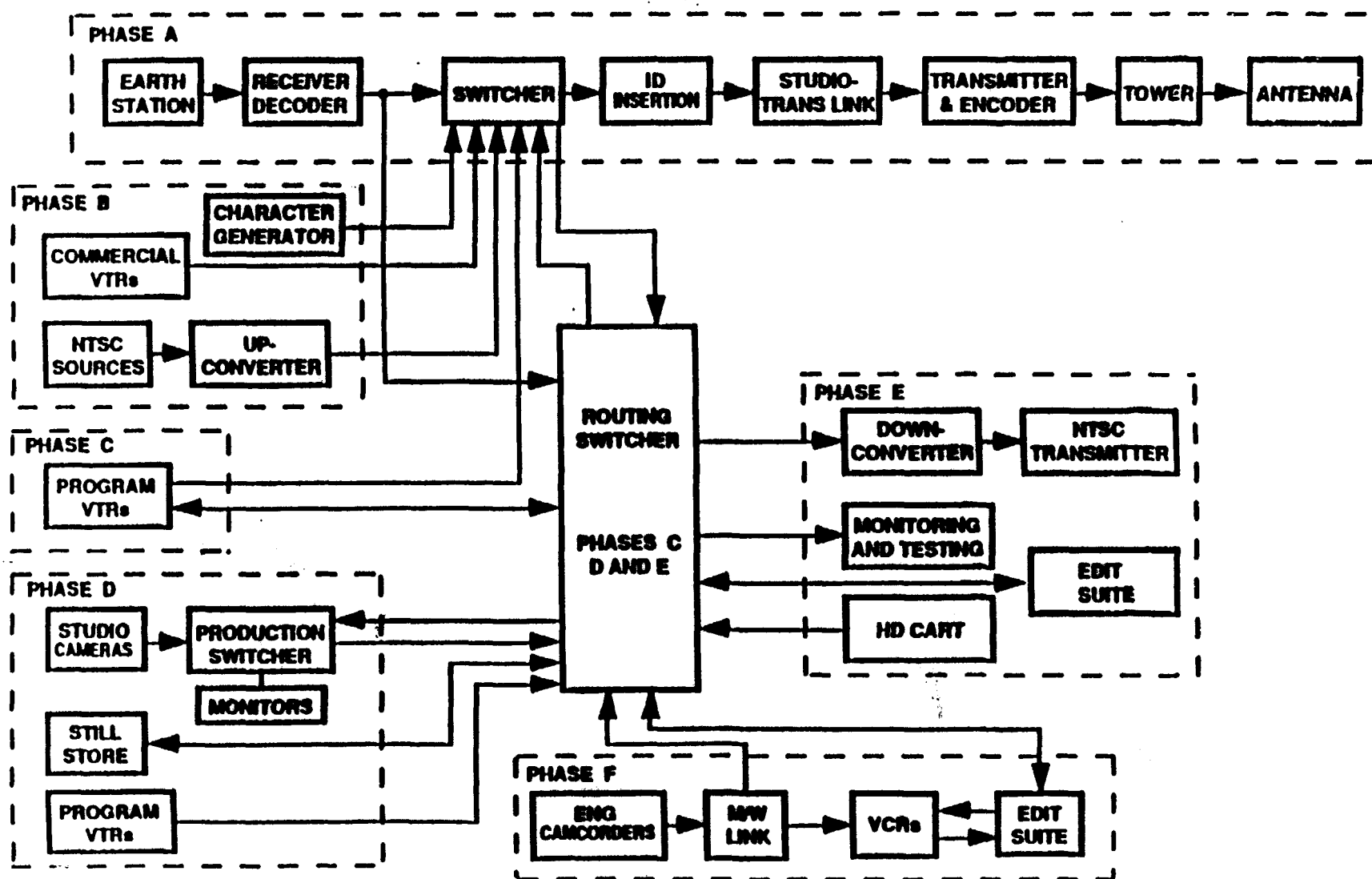


FIGURE 3



Phase D: - Local Origination

Requires the addition of studio cameras, VTRs, and a production switcher.

Phase E: - Final Plant Conversion

Calls for the addition of a down-converter in order to feed HD programs to the NTSC transmitter for simulcast operations. An HD cart machine for the playback of commercials is added in this phase, together with test and monitoring facilities.

Phase F: - ENG

Requires the addition of HD camcorders, VCRs, and editing facilities.

Existing microwave links will be used.

5. FINANCIAL ASSUMPTIONS

In assessing the costs of implementing each phase of the conversion to HDTV, the following financial assumptions have been made.

5.1. Labor

The cost estimates include the labor for installation. For broadcasters who capitalize labor for installation, the labor cost for the type of equipment and systems considered is assumed to be 20 percent of the capital equipment cost.

Some stations will use in-house technical labor for installation, while others will employ outside contractors. The amount of labor required for installation will vary widely with the physical conditions and equipment existing at individual stations. Accounting procedures for recording labor costs also vary from station to station. Overall, however, a 20 per cent factor for labor is believed reasonable.

5.2. Transmission Signal Format

A number of HDTV proponents have proposed systems using lower power transmitters and lower ERP than NTSC. The transmitter power could be 10-20 dB less than a current NTSC transmitter to provide similar coverage.

For example, a typical NTSC UHF transmitter has an ERP of 1 megawatt, while a HDTV transmitter would have an ERP ten to one hundred times less. Such reductions in power also lead directly to reduced costs for primary power.

This is important because the HDTV system adopted for terrestrial transmission must allow the simulcast transmitter to be located approximately 100 miles from a co-channel NTSC television station without causing interference, while providing HDTV service to a comparable area.

The resultant smaller antennas and transmission lines will reduce the weight required to be mounted on the tower. Even more important, the smaller antennas reduce the wind load that a tower must support.

By minimizing the incremental loading, the need for tower modifications, or for an additional tower, is eliminated, and substantial cost savings are achievable.

For purposes of the following analysis, it is assumed that stations will not require a new tower in order to add a simulcast HDTV antenna. This assumption is discussed in Appendix A.

5.3. Economies of Scale

It is assumed that with each doubling of the number of units of equipment ordered annually for HDTV broadcasting, the cost and price of equipment will be reduced by 10% of the initial cost, as equipment design is refined and manufacturing productivity is improved.

Much of the equipment required for conversion is new and initial prices are those currently quoted for prototype and pre-production samples. It is anticipated that prices for production runs of equipment even for the first stations to convert may well be lower than those assumed here.

Moreover, some equipment involved in the conversion process will be sold in many other markets, including program production and post production, medical, printing and publishing, corporate training and communication, and non-broadcast video communication. Such non-broadcast applications

will involve equipment quantities far exceeding broadcast needs, and in the future lead to significant economies of scale.

Finally, much of the equipment employed for HDTV broadcasting will be the same or similar to that employed in other countries introducing HDTV service.

Although manufacturers frequently gain market entry by pricing early production units at cost or less, no such assumptions have been made herein, and the prices of equipment used for the conversion of the first 30 stations are, as noted above, the currently quoted prices, often for prototype equipment.

As a result of these considerations, a 10 percent reduction in equipment cost for each doubling of the number of units used for HDTV broadcasting is considered a reasonable, although moderately aggressive, assumption.

5.4. Reuse of Existing Equipment

Existing plant, studio and control room audio equipment will be reused, not replaced. Since all proponent systems include multi-channel digital audio, stereo conversion of local origination is assumed prior to HDTV conversion.

Studio lighting and sets are assumed to require little or no modification. Existing studio/control room/plant communication systems will be reused, not replaced.

6. CAPITAL COSTS

Figure 4 presents the anticipated costs for each phase of the conversion for each of the first 30 stations, (Group 1),

the next 40 stations, (Group 2)

the next 80 stations, (Group 3)

the next 160 stations, (Group 4)

the next 320 stations, (Group 5), and

the next 640 stations, (Group 6), for a total of 1270 stations.

The capital investment in HD equipment for each of the first 30 stations in Group 1 is projected to be \$11.6 million. This cost becomes progressively smaller for stations in each subsequent group. Thus, for stations in Group 5, the cost is \$6.9 million.

The estimated cost of converting ENG operations to high definition is not shown. HD ENG equipment with the light weight and small size of current professional camcorders is not yet developed, and cost assumptions have not been made. It is anticipated that such equipment will be available in quantity, at a reasonable incremental cost over replacement NTSC equipment, in the time frames envisioned, although it will also prove feasible to defer that investment for several years.

SIMULCAST HIGH DEFINITION TERRESTRIAL BROADCAST COSTS BY PHASE AND QUANTITY \$ THOUSANDS*

		GROUPS OF STATIONS ACQUIRING EQUIPMENT					
GROUP		1	2	3	4	5	6
NO. OF STATIONS		30	+40=70	+80=150	+160=310	+320=630	+640=1270
% TVHH SERVED		31	53	83	95	98	100
A - NETWORK PASS-THROUGH		1481	1333	1185	1037	889	741
B - LOCAL COMM. INSERTION		1652	1487	1322	1157	992	827
C - LOCAL PLAY OF SYNDICATED NON-NET PROGRAMS		1057	951	845	739	633	527
D - LOCAL ORIGATION		3277	2949	2621	2293	1965	1637
E - FINAL PLANT CONVERSION		4113	3702	3291	2880	2469	2058
TOTAL CAPITAL COST PER STATION		11,580	10,422	9,264	8,106	6,948	5,790

* IN 1990 DOLLARS

FIGURE 4



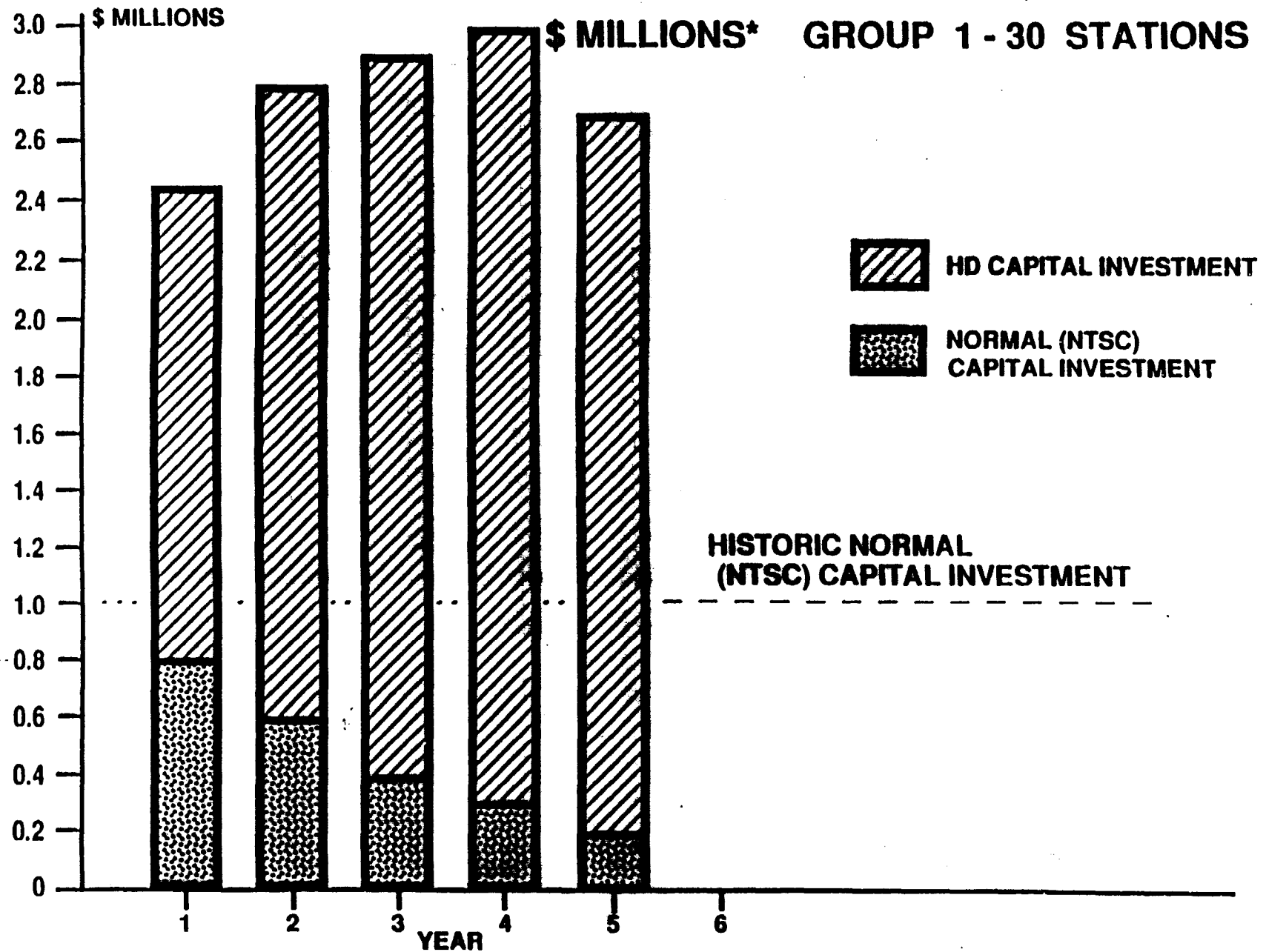
It may well be that, in the interim period prior to the local studio origination and ENG conversion, news and public affairs programs in NTSC will be subjectively improved by electronically artificially increasing the number of lines in the picture prior to transmission. Such "up-conversion" would be a relatively simple operation which would not improve picture definition or color rendition, but would have the subjective benefit of removing line structure in the picture.

In Figure 5, the capital equipment cost for Group 1 stations is presented as an annual cost for each year of the conversion process. Referring to Figure 5, the annual capital investment in HD equipment is shown in the upper part of each column, while the lower part represents the continuing, but declining, capital investment in normal (NTSC) equipment. --

As the conversion to HD proceeds year-by-year, the investment in NTSC equipment is seen to decline from its historic level of an assumed \$1.0 million indicated by the dotted line on the chart.

For the 30 stations in Group 1, it is projected that the conversion program can be completed in five years. Similarly, figure 6 shows the annual capital investments for the 40 stations of Group 2. Here the conversion program starts in Year 2 and is completed in six years. Annual investments are lower because the total investment is spread over a longer period than Group 1, and because of lower equipment costs as manufacturing efficiency improves. The total investment in HD equipment is \$10.4 million.

ANNUAL CAPITAL INVESTMENT IN HD EQUIPMENT



* IN 1990 DOLLARS

FIGURE 5



ANNUAL CAPITAL INVESTMENT IN HD EQUIPMENT

\$ MILLIONS*
GROUP 2 - 40 STATIONS

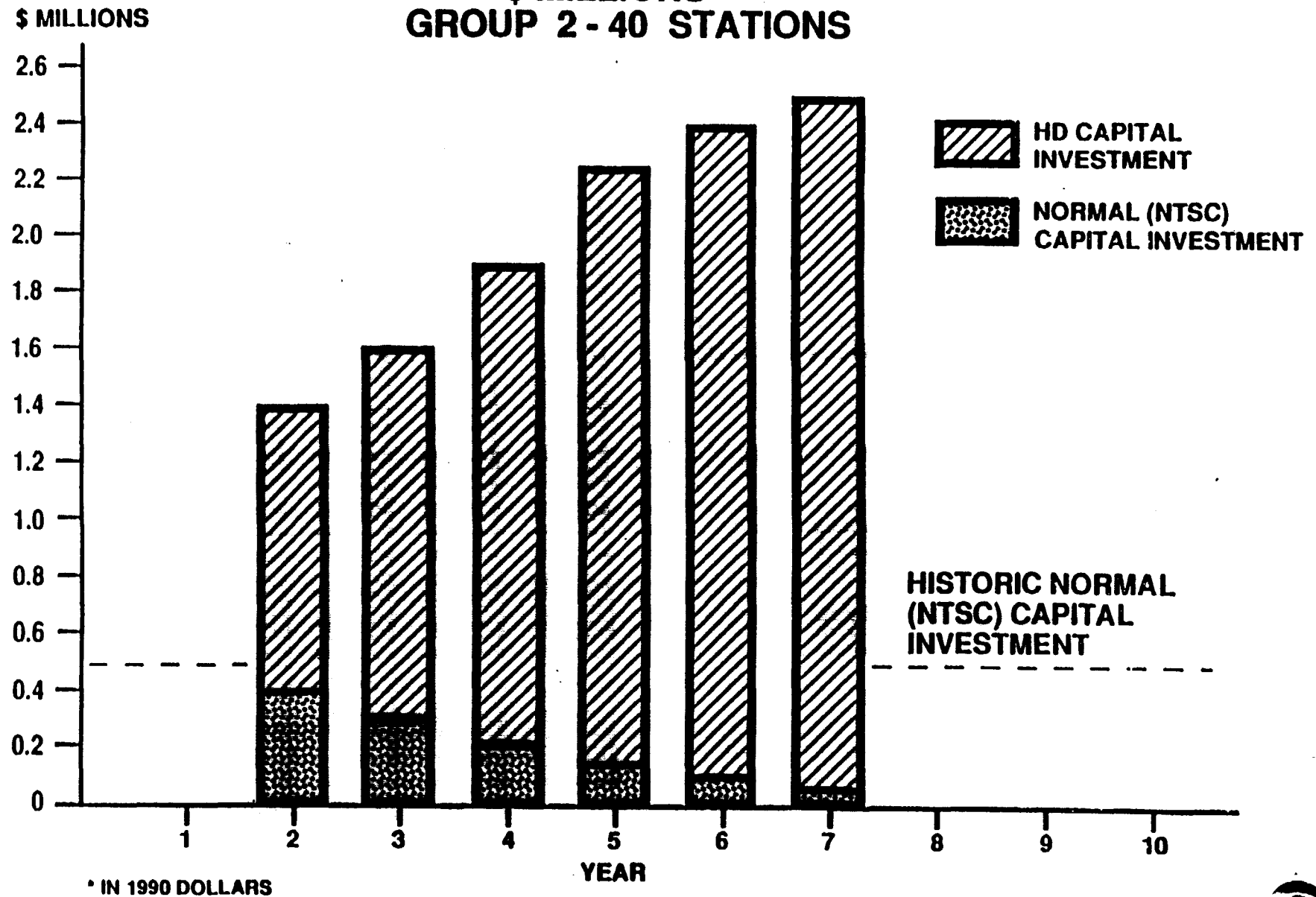
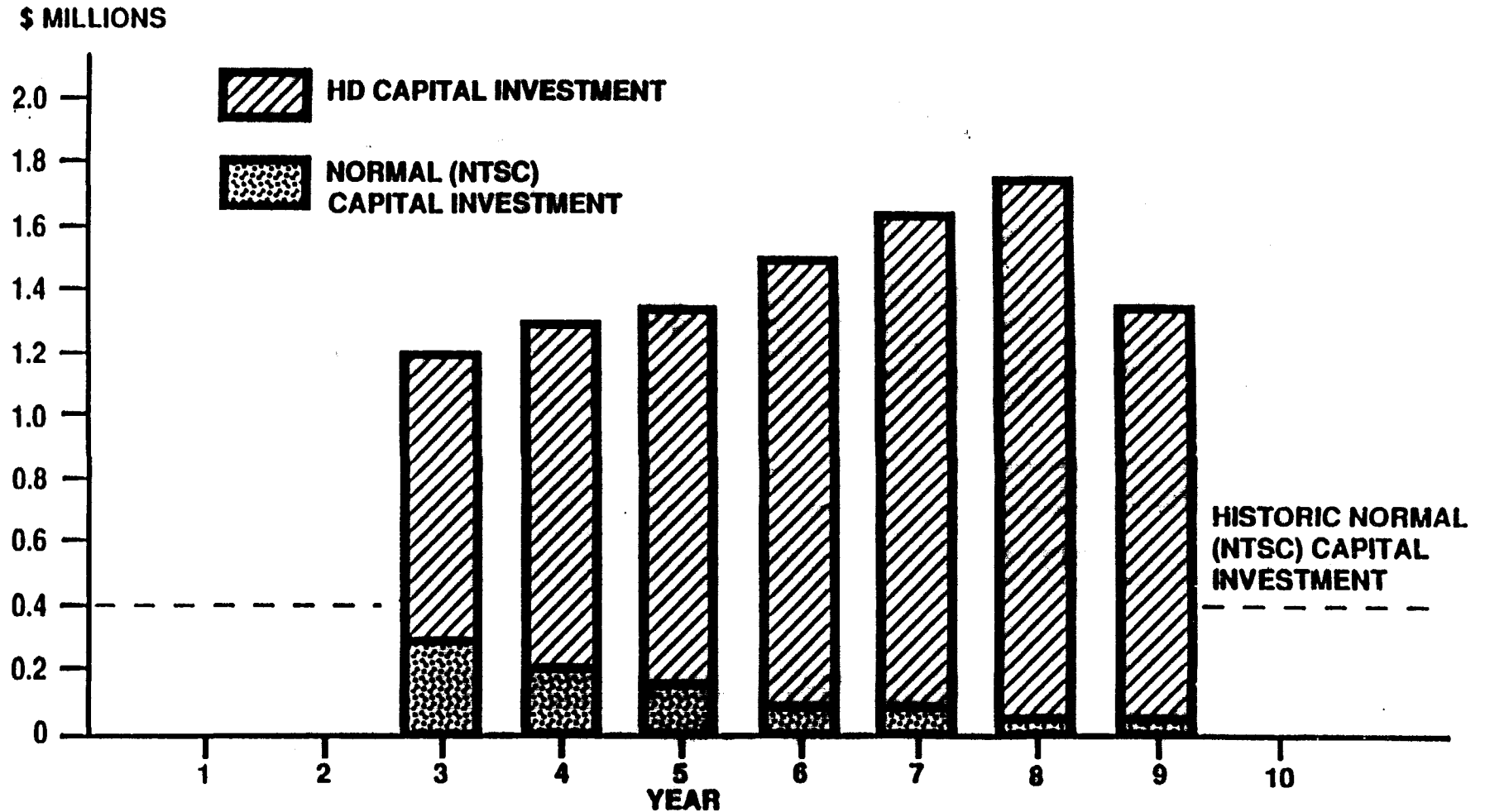


FIGURE 6



ANNUAL CAPITAL INVESTMENT IN HD EQUIPMENT \$ MILLIONS* GROUP 3 - 80 STATIONS

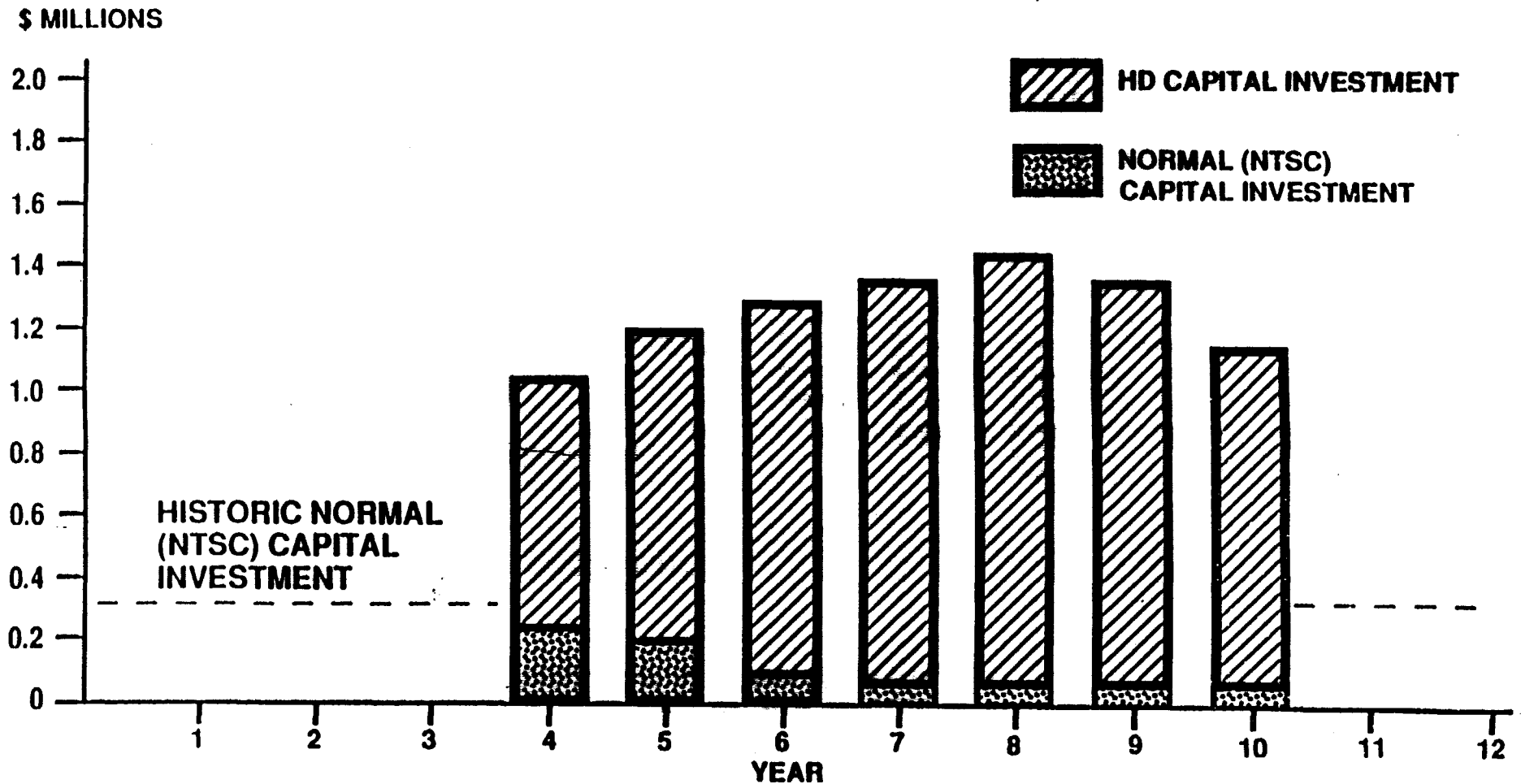


* IN 1990 DOLLARS

FIGURE 7



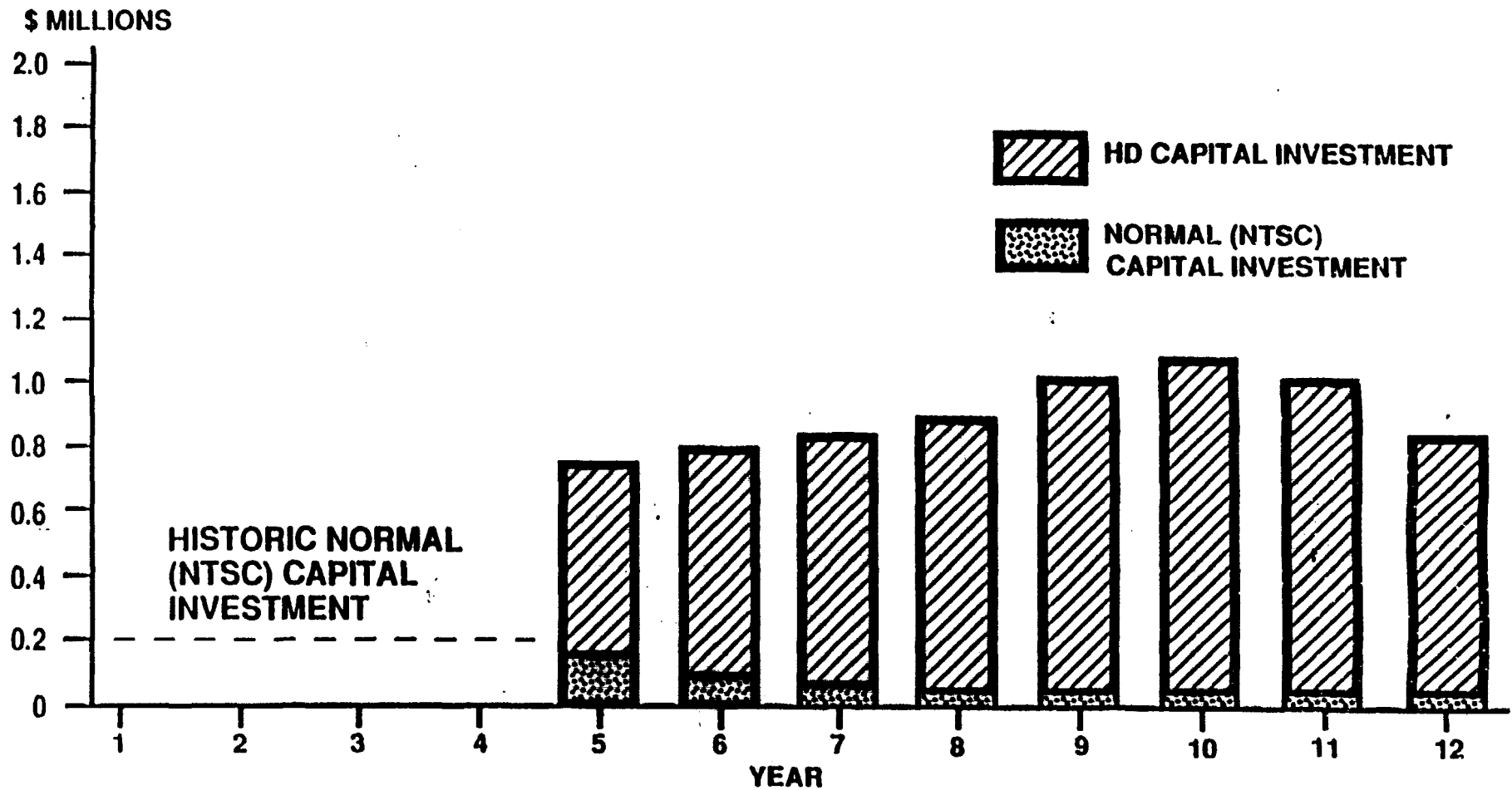
ANNUAL CAPITAL INVESTMENT IN HD EQUIPMENT \$ MILLIONS* GROUP 4 - 160 STATIONS



* IN 1990 DOLLARS

FIGURE 8

ANNUAL CAPITAL INVESTMENT IN HD EQUIPMENT \$ MILLIONS* GROUP 5 - 320 STATIONS



* IN 1990 DOLLARS

FIGURE 9



Figures 7, 8, and 9 show similar data for successively larger groups of stations (Groups 3, 4, and 5) which start the conversion program in later years and which spread the conversion process over longer periods. Thus in Group 5, the 160 stations involved are assumed to start conversion in Year 5 and to complete the conversion in Year 12, 8 years later (Figure 9).

6.1. Incremental Capital Cost

While the total capital investment in HD equipment is 11.6 million for each station in Group 1, shown in Figure 4, the incremental cost for the five-year period is the sum of the expenditures above the historic normal capital investment in NTSC equipment, which is \$assumed to be 1.0 million per year, or \$5.0 million over the five-year conversion period. Thus the incremental cost of conversion, based on these assumptions, is 11.6 million less \$5.0 million, or 6.6 million, plus the remaining cost of maintaining some NTSC equipment during the conversion, shown in Figure 5. This analysis produces a total incremental cost of \$8.9 million.

For the 40 stations in Group 2, the total capital investment in HD equipment is \$10.4 million, (Fig. 4), and the historic level of capital investment in NTSC equipment is \$0.5 million for year (Figure 6). The total net incremental cost for a station in this group is then $\$10.4 - (6 \times 0.5) = \7.4 million, to which must be added the remaining NTSC equipment cost of \$1.2 million, for a total of \$8.6 million.